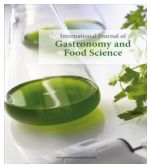

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Scientific Paper

The influence of addition of *Borago officinalis* with antibacterial activity on the sensory quality of fresh pasta

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Abstract

Borage (*Borago officinalis* L.) is a herbaceous plant of the *Boraginaceae* family cultivated throughout the world for several purposes, including food preparations, mainly beverages and salads. Some Italian recipes use borage as a food ingredient, in particular as condiment for pasta. The aqueous extract (AE) from borage leaves can act as biopreservative in foods due to its inhibition towards the main foodborne pathogen bacteria. Fresh pasta, due to the high content of water, is a food product with a limited shelf life. In order to test the suitability of borage to produce fresh pasta with a prolonged shelf life, borage AE was used in dried form as a raw material for the production of tagliatelle pasta. Pasta produced with fresh borage was used as green tagliatelle control, while pasta produced without borage was used as white tagliatelle control. The colour of the three tagliatelle pasta types was different. A sensory panel was used to test the appreciation of these products prepared following three recipes with Sicilian ingredients. Both pastas produced with borage were preferred to control pasta with any preparation based on cheese, meat or fish as principal flavour ingredient. The present study demonstrated the suitability of borage AE as natural preservative for fresh pasta production.

Keywords: Aqueous extracts; Antibacterial activity; Borage; Fresh pasta; Sensory evaluation

Introduction

In the last few years, we are experiencing the 'green consumerism' life-style and people are demanding more foods that are organic and with reduced levels of chemical preservatives for conservation (Burt, 2004). On the other hand, the request for foods with high convenience of use, that are 'ready to eat', is increasing. This products are characterised by a short shelf life, that needs to be enhanced to follow the current trend of consumers' habit to purchase food items more often weekly rather than daily. For this reason, prepared meals, foods and single ingredients sold in retail markets must have a high microbial stability to prevent the occurrence of foodborne illness. Hygienic food handling aims to control the presence of pathogens in foods by controlling the contamination, growth, and survival of microbial pathogens (Adams and Motarjemi, 1999).

Italy is the world's largest country consumer of pasta, with an average consumption per capita of about 26 kg per year (UN.A.F.P.A., 2012). Pasta is typically commercially available in dried form, but several fresh pasta typologies are commonly produced in Italy and used for traditional local culinary uses. Although in Italy there are small specialized shops selling fresh pasta produced at artisanal level, this product is mostly available in a pre-packed form and distributed by the large retail chains. Fresh pasta contains a moisture content above 24% and requires a refrigerated storage below 4 °C (Costa et al., 2010). In Italy, the sell-by date for this product must be no later than five days from the date of manufacture (Presidential Decree no. 187, 2001).

Unlike dried pasta that is made with durum (*Triticum durum*) wheat flour, fresh pasta is commonly obtained by processing soft (*Triticum aestivum*) wheat flour. Egg pasta is the most common fresh pasta produced and consumed in Italy, but some regional

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recipes include fresh pasta made with mixtures of wheat flour and other ingredients, such as pumpkin flesh, spinach, sepia, etc., mainly used as colouring and flavouring agents. The addition of ingredients with antimicrobial activities could be of paramount importance to prolong the shelf life of fresh pasta without compromising its 'natural' image. Natural alternatives to chemical preservatives generally include microbial inhibitors (e.g. bacteriocins and antifungal compounds) and vegetable by-products (e.g. essential oils and water extracts) (Settanni and Moschetti, 2014). Hence, the preparation of fresh pasta with vegetables containing specific compounds that inhibit the growth of undesired (pathogenic/spoilage) microbial agents could represent an interesting strategy to prolong the shelf-life of foods.

In a recent paper of our research group, the antibacterial activities of *Brassica juncea* and *Borago officinalis* aqueous extracts (AEs) were investigated (Miceli et al., 2014). Interestingly, both AEs were able to inhibit *in vitro* several strains of *Listeria monocytogenes*, *Staphylococcus aureus*, *Enterobacter* spp. and *Salmonella enterica*, that are commonly associated with foodborne diseases. However, the *in situ* applications of both AEs in food model systems indicated that, at the concentrations active against the test bacteria, *B. officinalis* is sensorially preferred over *B. juncea*. Those data suggested a possible application of *B. officinalis* AE as food biopreservative.

Borage (*B. officinalis* L.) is a hairy annual herbaceous plant of the *Boraginaceae* family native to Europe and North Africa widely spread in many Mediterranean countries. This plant was cultivated throughout the world traditionally for culinary and folk medicinal uses (Hassan Gilani et al., 2007). Borage has been defined as a "power food" of the future because of its content on unsaturated fatty acids (Río-Celestino et al., 2008). Leaves, stems and flower are eaten raw or cooked according to regional recipes and traditional local culinary uses. The basal leaves and the aerial parts are eaten fried, boiled, stewed or used to prepare green pasta or as stuffing for pies, ravioli and tortelli (Lentini and Venza, 2007). Borage flowers are one of the few truly blue-coloured edible substances. They are added to salads to which add a light cucumber flavour and often used to decorate beverages and desserts.

In order to extend the exploitation of *B. officinalis* as biopreservative agent, the main aim of this work was to evaluate the suitability of borage AE, in dried form, as raw materials to produce fresh pasta. To this purpose, fresh pasta was also produced with fresh borage. Both pasta productions were seasoned in different ways, following three new recipes with Sicilian ingredients, and subjected to the sensory analysis. The pasta samples were also analysed by colorimeter to investigate the difference in terms of colour.

Materials and methods

Plant material and extract preparation

Plants of *B. officinalis* L. were grown during autumn–spring in the experimental field of the Department of Agricultural and Forest Science, University of Palermo (38°9′28″N, 13°20′3″E). Plants were collected at flowering and leaves were immediately separated, cleaned, washed, comminuted and mixed. Leaf bulk was divided in two aliquots, one to be used fresh for traditional borage tagliatelle (TBT) and the other one to be subjected to the extraction of the aqueous fraction for innovative borage tagliatelle (IBT) production. The aqueous extract (AE) was prepared according to the method of García-Iñiguez de Ciriano et al. (2009). Water extraction was performed in triplicate. The extract was freeze-dried, previously freezing at −80 °C and used, after rehydration, with distilled water. After freeze-drying, the yield in powder was 2.60 ± 0.08 g from 100 g of fresh leaves of borage.

Tagliatelle production

TBT pasta dough was prepared with 1000 g of commercial wheat flour (Il Molino Chiavazza, Casalgrasso, Italy), 430 g of boiled borage leaves and 250 mL of tap water. IBT pasta dough was prepared with 1000 g of commercial wheat flour, 10 g of borage AE (rehydrated to a final volume of 50 mL) and 500 mL of tap water. A control tagliatelle (CT) pasta was produced with 1000 g of commercial wheat flour and 550 mL of tap water. Ingredients for each pasta production were mixed for 15 min by a pasta maker Kenwood chef—speed 1 (De Longhi Appliances s.r.l., Treviso, Italy) to achieve homogenous doughs. They were left resting for 5 min at room temperature before extruding into tagliatelle with the moulder iPasta (Imperia, Moncalieri, Italy).

All tagliatelle pasta samples were cooked at the optimal cooking time (five minutes as previously evaluated by cooking each tagliatelle pasta type for different times; cooking time were not significantly different among the three pastas investigated).

Cuisine test

The visual aspect of coloured tagliatelle pasta and the peculiar flavour characteristics of borage in fresh and dried forms may be perceived differently according to serving and dressing characteristics. Hence, some new recipes suitable for these type of tagliatelle pasta (Fig. 1) were evaluated:

- *Elisir di Sicilia* (Elixir of Sicily), olive oil of "Nocellara del Belìce" cultivar, fresh Caciocavallo Palermitano cheese and parsil.
- *Mediterraneo in zuppetta* (Mediterranean soup), a fish sauce prepared with redfish, mullet and tub gurnard added with cooked borage leaves at the moment of dressing.
- *Nebrodi che passione* (Fondness for Nebrodi mountains), a dressing of sausages of the Sicilian swine breed "Suino Nero dei Nebrodi" with local artichokes and rosemary.

Colour determination

Colour was measured on four points of pasta surface of four tagliatelle of each sample, before and after cooking, by means of a colorimeter (Chroma Meter CR-400C, Minolta, Osaka,

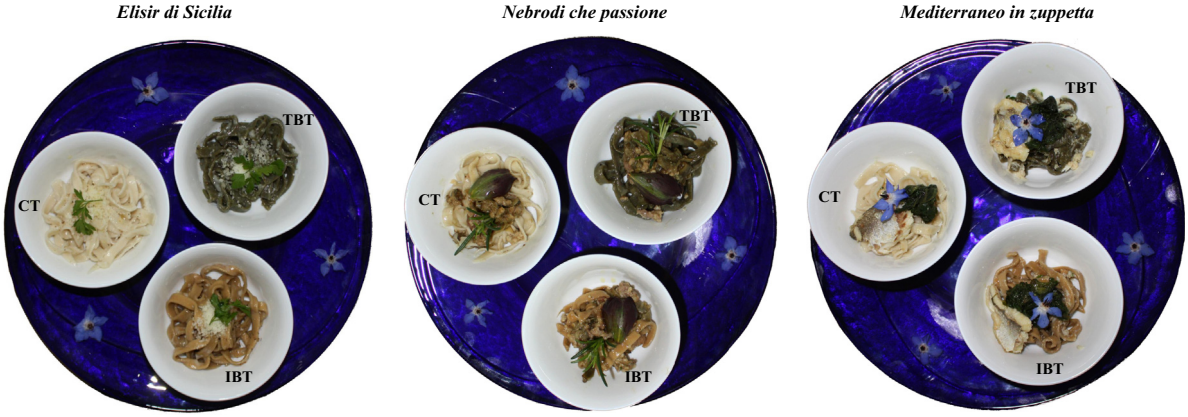

Fig. 1. Cuisine applications of tagliatelle pasta. Abbreviations: CT, control tagliatelle; TBT, traditional borage tagliatelle; IBT, innovative borage tagliatelle.

Japan). Parameters L^*, a^* and b^* were recorded. Hue angle (h°) and Chroma (C^*) were calculated as $h^\circ = \arctan(b^*/a^*)$ when $a^* > 0$ and $b^* > 0$, or as $h^\circ = 180^\circ + \arctan(b^*/a^*)$ when $a^* < 0$ and $b > 0$ (McGuire, 1992) and $C^* = (a^{*2} + b^{*2})^{1/2}$. Colour determination was performed before and after cooking.

Sensory analysis

The effect of the addition of the different forms (fresh and dried) of *B. officinalis* on the final characteristics of tagliatelle was evaluated by sensory analysis on pasta samples after seasoning. Fresh pasta prepared without *B. officinalis* was used for sensory comparison. The descriptive panel consisted of seventeen judges (seven females and 10 males, 28–61 years old) familiar with the sensory analysis of foods, but not specifically trained in the evaluation of fresh pasta. The judges were asked to score 14 descriptors regarding the aspect (attractiveness/pleasantness, colour intensity, colour pleasantness, presence of spot and uniformity of colour and structure), the smell (strength of odours, vegetable), the taste (vegetable, earthy, mealy, harmonious) and the tactile sensations (adhesiveness, granular, consistency, elasticity). Moreover, they were asked to score the overall sensory quality. The sensory analysis was conducted following the ISO 13299 (2003) indications. The panellists performed the analysis in individual chambers and had no specific information about the experimental design. All pasta samples were singly administered in white dishes in a randomised order.

Statistical analysis

Data were statistically analysed using the ANOVA procedure with the software SAS 2004, version 9.1.2 (Statistical Analysis System Institute Inc., Cary, NC, USA). Differences between means were determined by LSD multiple range test.

Results and discussion

Aspect of pasta

All colour parameters were analysed by a statistical model including the effect of tagliatelle pasta type, cooking and their interactions. The colour of the three tagliatelle pasta types differed for almost all colour parameters considered (Table 1).

Table 1
Colour characteristics of tagliatelle pasta.

Tagliatelle	Cooking	L^*	a^*	b^*	Chroma	Hue$^\circ$
CT	Raw	[1]76.5a	1.3c	13.0b	13.1b	5.7d
	Cooked	73.2a	0.8d	9.8c	9.9c	4.4d
TBT	Raw	63.1b	−1.1e	10.2c	10.3c	174.1a
	Cooked	41.0c	−1.8f	14.2b	14.3b	172.8a
IBT	Raw	69.0a	3.0b	13.9b	14.2b	12.1b
	Cooked	57.9b	3.9a	23.6a	24.0a	9.4c
Significance						
Tagliatelle		***[2]	***	***	***	***
Cooking		***	ns	***	***	***
Tagliatelle × Cooking		***	***	***	***	ns

[1]Data within a column followed by the same letter are not significantly different according to LSD multiple range test. [2]Significance, ns not significant; * significant at $P < 0.05$; ** significant at $P < 0.01$; *** significant at $P < 0.001$.

Within each tagliatelle pasta, except L^* and Hue$^\circ$ for CT and Hue$^\circ$ for TBT, the colour parameters changed after cooking, and especially for IBT all parameters resulted statistically different. The colour of tagliatelle pasta with *B. officinalis* (fresh or dried) get darker and more vivid after cooking, whereas CT reduced its chroma; the use of AE (IBT) determined a reddish/brown colour of tagliatelle pasta that increased its red component (a^*) and reduced the hue angle after cooking. In general, only a^* was not statistically significant for cooking effect, whereas Hue$^\circ$ was not statistically significant for the interaction tagliatelle × cooking.

Colour is one of the elements that mostly characterises product quality and consumer acceptance. As expected the addition of borage changed the colour of the tagliatelle pasta, ranging from the whitish colour for control tagliatelle pasta, through dark green for TBT to a distinctive reddish/brown colour for IBT. Coloured pasta gained success and were well accepted by consumers. Thus, the colour introduced by the addition of fresh borage leaves or dried borage AE is not expected to have any negative effect on the consumer acceptance.

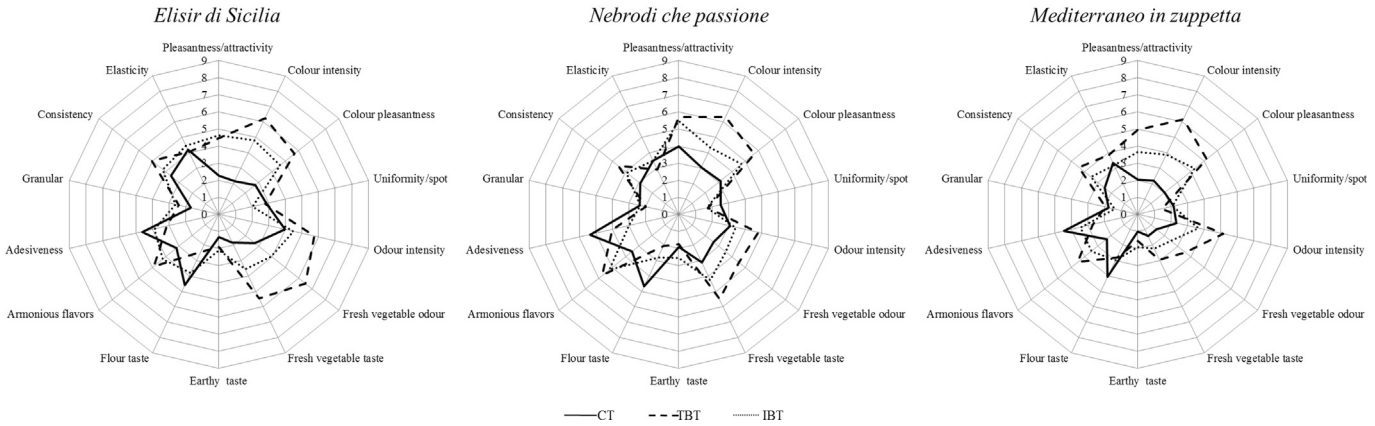

Fig. 2. Sensory analysis of tagliatelle pasta. Symbols: ——, CT; — —, TBT; ••••, IBT. Abbreviations: CT, control tagliatelle; TBT, traditional borage tagliatelle; IBT, innovative borage tagliatelle.

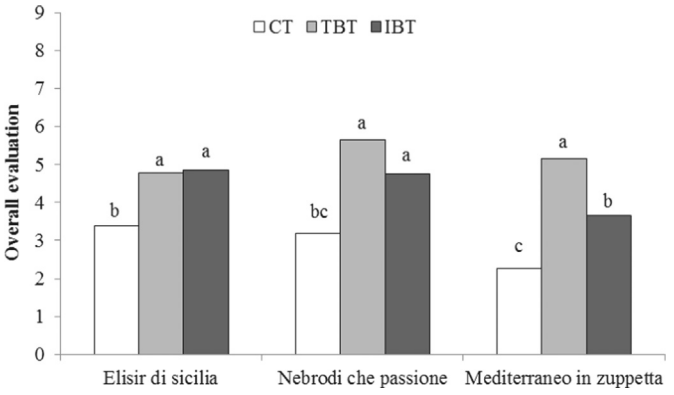

Fig. 3. Overall evaluation of tagliatelle pasta (bars with the same letters are not significantly different ($P \leq 0.05$) according to ANOVA and LSD multiple-range test).

Sensory evaluation

The sensory evaluation carried out by the graders recognised the three tagliatelle pasta types as different for all three recipes followed for seasoning (Fig. 2). TBT was characterised by the highest scores of colour intensity, colour pleasantness, odour intensity, fresh vegetable taste and odour, armonious flavours and consistency for all recipes. However, the values registered for fresh vegetable taste and odour of TBT prepared with *Mediterraneo in zuppetta* sauce were lower than those observed for the other two recipes. In any recipe, CT showed the highest values for adhesiveness and flour taste, while IBT for earthy taste. The highest overall evaluation with *Mediterraneo in zuppetta* and *Nebrodi che passione* sauce was displayed by TBT (Fig. 3). TBT and IBT reached almost the same overall evaluation score for the *Elisir di Sicilia* recipe.

The sensorial quality of fresh pasta played a significant role in determining the product acceptability. From this perspective, the three recipes determined a good appreciation of both IBT and TBT. However, results from panel test suggested that borage AE as natural preservative could be advantageously used to produce fresh pasta to be seasoned with meat and/or cheese preparations. The sensorial analysis is of paramount importance to test the suitability of alternative preservatives in fresh pasta and verify how the addition of new "ingredients" affect the sensorial properties of the final products (Del Nobile et al., 2009; Costa et al., 2010).

The use of fresh borage as comparison in pasta production is based on the assumption that traditional products are integral part of the food culture. The innovations regarding traditional procedures using typical ingredients or components of the local culinary tradition might give the resulting foods a certain familiarity (Settanni and Moschetti, 2014). With this in mind the addition of borage AE to the mixture of ingredients for pasta production could be perceived as "natural" by consumers and, thus, its flavour well accepted during the sensory evaluation.

Conclusions

Nowadays, the use of chemical preservatives and bacteriostatic compounds that avoid the proliferation of microorganisms is allowed in fresh pasta (FDA, 2006). In view to apply natural products as alternative biopreservatives for foods, the AE of borage in dried form was used as ingredient to produce fresh pasta. The main objective of this study was to evaluate the appreciation of the new gastronomic experimentation by consumers. To this purpose, three recipes obtained through the use of Sicilian ingredients were developed, in order to test the suitability of the different combinations of flavours. The colour of the innovative pasta was different from that of the traditional pasta produced with fresh borage and both differed from the control white tagliatelle pasta, before and after cooking. Both borage containing pasta productions were preferred to control pasta with any preparation based on cheese, meat or fish as main flavour ingredient. Between IBT and TBT, the latter was greatly appreciated with all recipes, but IBT resulted much more appreciated than control pasta, especially for *Elisir di Sicilia* and *Nebrodi che passione* cuisine applications. Based on the results obtained in this study, works will be prepared to evaluate the shelf-life of IBT

and the *in-vivo* efficacy of borage AE with different refrigerated fresh pasta formats.

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